UDC 551.515.2(265.2)"1968"

# CORRESPONDENCE

## Comments on "The Eastern Pacific Hurricane Season of 1968"

L. F. HUBERT

National Environmental Satellite Center, ESSA, Washington, D.C.

Mr. Denney's paper (1969) is a milestone. It is the first description of a complete hurricane season for an area where our storm climatology has been deplorable. He has shown that with routine satellite coverage, this hiatus can be closed in a very respectable manner. I hope that such a summary can be an annual feature in the *Monthly Weather Review.*

However, part of Mr. Denney's deduction of cloud-level inflow is not correct. Where he deduces inflow from spiral bands of stratocumuli, ATS-1 picture sequences show no inflow. Time-lapse movies from geostationary satellites reveal cloud motions. Wind estimates made from these motions are immeasurably better than the inferences of wind that we have been forced to make from individual pictures. Two examples are shown here on ATS-1 pictures.

Figures 1 and 2 correspond to Mr. Denney's figures 9 and 11. The superimposed arrows illustrate two types of motion that were revealed by time-lapse movies. The narrow solid arrows represent the displacement of individual cloud elements—the advection of those clouds by the wind. The broad arrowheads along the broken line segments indicate the motion of cloud band edges—the propagation of these cloud bands by gravity waves on a low-level stable layer (Hubert, 1969).

Such analyses show that wind direction is frequently not along the stratocumuli band alinement, nor does it cut across the bands at any fixed angle. Especially in the west and southwest quadrants of figure 2, the cloud band orientation and winds are quite different.

The flow shown by the arrows is representative of the cloud layer, at a height of perhaps 2,000 to 5,000 ft. For that reason, Mr. Denney's interpretation that these curved bands mark spiral inflow is not correct in some cases. Indeed, these examples caution us against making such an interpretation. Nonetheless, cold inflow may exist. The surface flow probably was deflected to the left of these cloud-level winds. Inflow, where it existed, may have occurred in a shallow subcloud layer.

To summarize, these examples demonstrate the critical importance of geostationary satellite data. Time-lapse

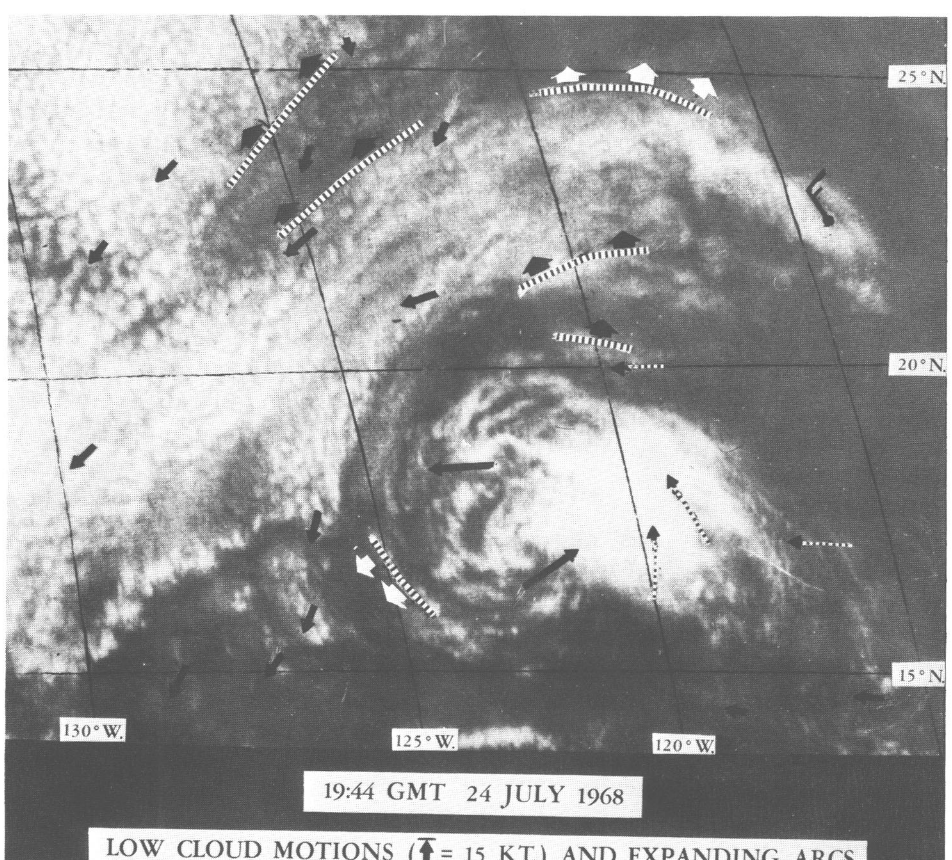


FIGURE 1.—ATS-1 photo of tropical storm Diana and derived cloud motion. Barbed arrows show ship wind observation. Length of solid arrows is proportional to seed of small cloud elements. Dotted lines with arrowheads show cloud direction where no speed was measured. Broad arrowheads normal to arc segments indicate direction of band edge motion.

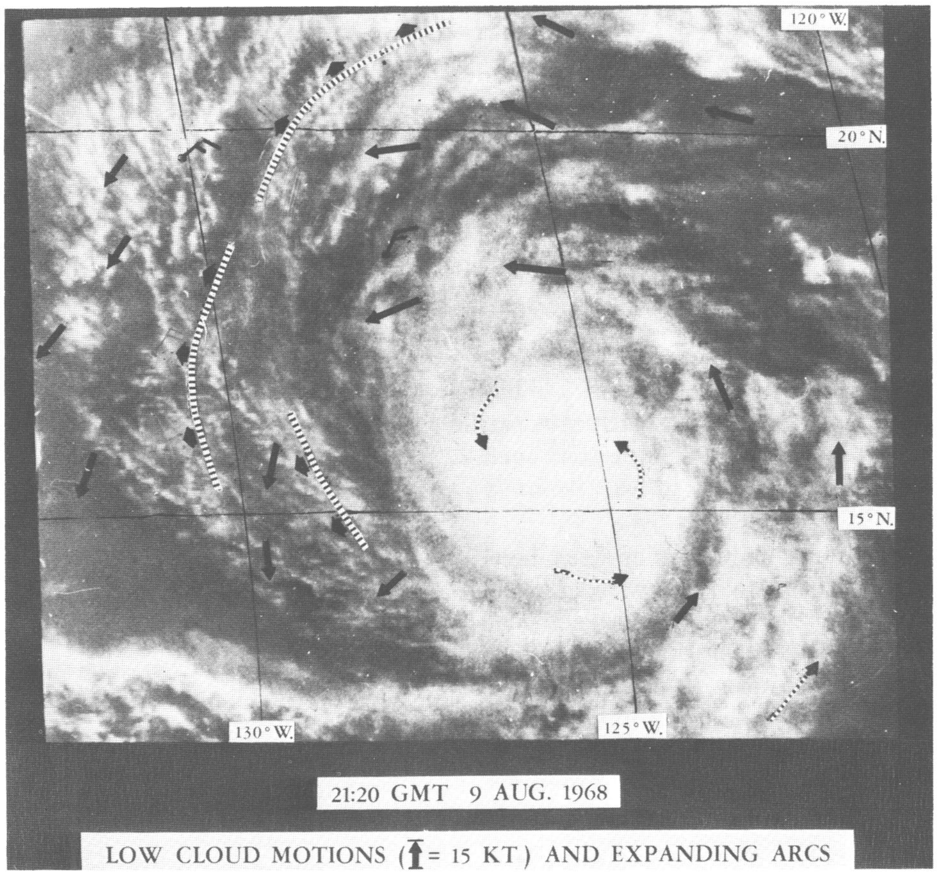


FIGURE 2.—ATS–1 photo of tropical storm Fernanda. Symbols are the same as those in figure 1.

movies show that we cannot accept these spiral bands as direct evidence of cool inflow. Deducing the field of motion from cloud patterns is complex. We still have much to learn, but already it is clear that cloud band orientation and wind direction can be quite different. Applications Technology Satellite (ATS) analyses show this difference to be particularly characteristic of cloud bands in shallow stratocumulus.

## REFERENCES

Denney, W. J., "The Eastern Pacific Hurricane Season of 1968," *Monthly Weather Review*, Vol 97, No. 3, Mar. 1969, pp. 207–224.

Hubert, L. F., "Tropical Storm Peripheral Gravity Waves," paper presented at the American Meteorological Society Meeting, New York, Jan. 20–23 1969.

# Reply

W. J. DENNEY

Weather Bureau Forcast Office, ESSA, San Francisco, Calif.

Mr. Hubert's comments are much appreciated. It is hoped that geostationary satellite picture sequences will be available for the routine operations of a hurricane season in the near future.

Efforts at detection of cool low-level inflow to 1968 eastern north Pacific hurricanes were based, in most instances, on finding a tongue of stratocumulus formed through the drawing action of the outer storm circulation on an extensive cloud layer. Such a tongue was commonly found around the stormward edge of low clouds in the circulation of the subtropical High.

Low-level inflow was assumed to exist in all storms having apparent cirrus production to indicate a central convective chimney of the sort postulated by the standard hurricane model. Winds were not assumed parallel to the stratocumuli bands, but surprise must be admitted that they are not more nearly so.

Mr. Hubert's wind determinations from ATS–1 pictures seem to indicate that most of the clouds of the broad spiral band into the southwest side of Fernanda and within about 300 n.mi. of the hurricane center (fig. 2) have a trajectory from the north side of the hurricane. The slight extension of trade wind stratocumulus into the storm circulation just happened to coincide with a spiral band rotating around the hurricane. The report on 1968 hurricanes would then be in error in having the entire spiral band represent a tongue of trade wind air. The fact that the hurricane weakened only slowly after August 9 was the basis for judgment that cool inflow had been "limited." Mr. Hubert's wind analysis clarifies the limitation.

The picture of Diana (fig. 1) corresponds to the ESSA–6 picture used in my report to illustrate detection of the stoppage of a tropical storm convective chimney through the displacement of a dissipating cirrus cap from the residual lower cloud vortex. The 200-mi-diameter cloud mass centered on 120° W. is the cirrus cap that had been centered over the vortex shown near 17° N., 122° W. Since there is little evidence of cirrus production over the lower cloud (middle and low cloud) vortex, little or no low-level inflow would be expected.